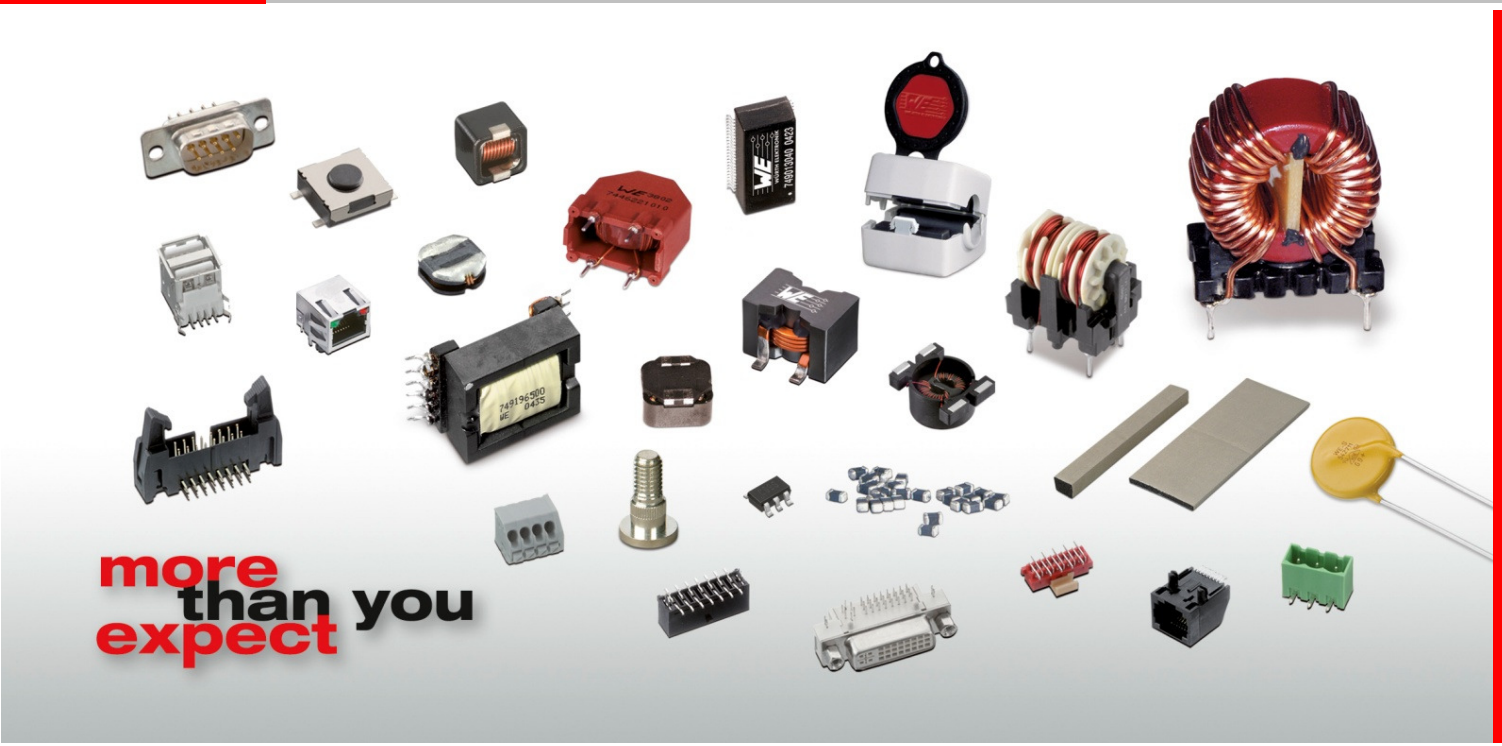
Microwave &RF

AFCEM

WÜRTH ELEKTRONIK

EMC Basics



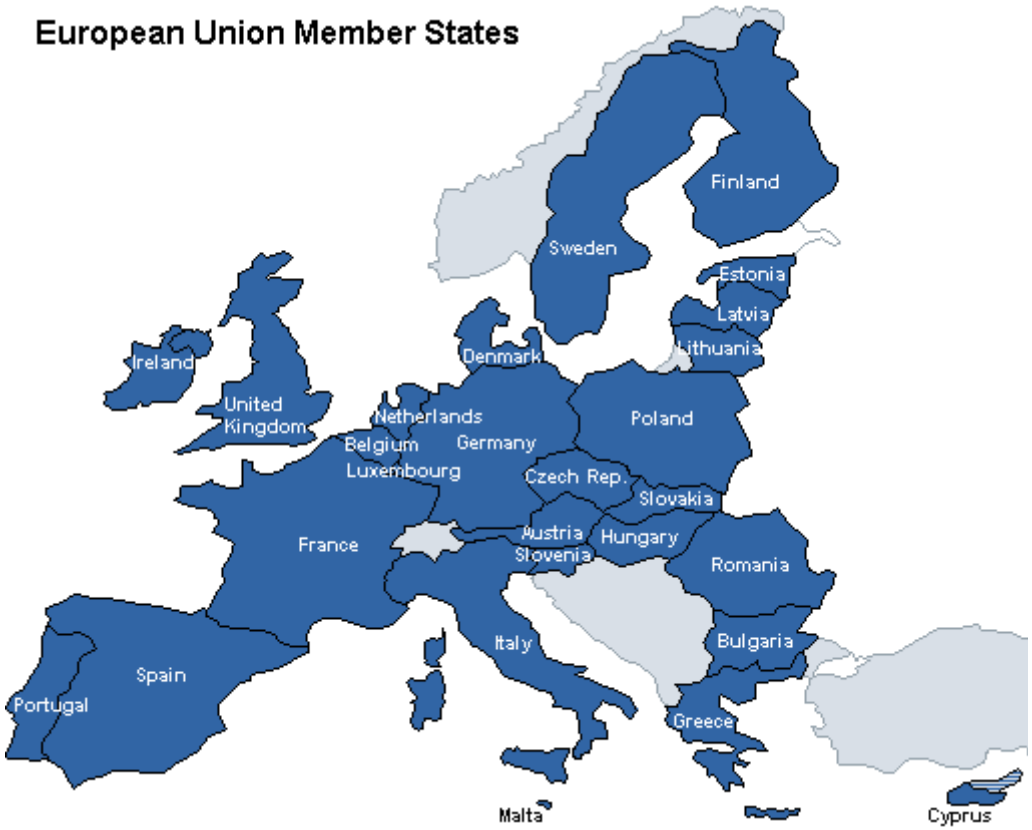
Speaker : Alain Lafuente

Alain.lafuente@we-online.com

WHAT IS EMC?

CE Marking

- With the formation of the single European market, standardization was required to remove technical barriers to trade.
- New Approach Directives were introduced to remove these barriers to trade
- 22 New Approach Directives
  - Electro Magnetic Compatibility (EMC)
  - Low Voltage Directive (LVD)
  - Medical Devices Directive (MDD)



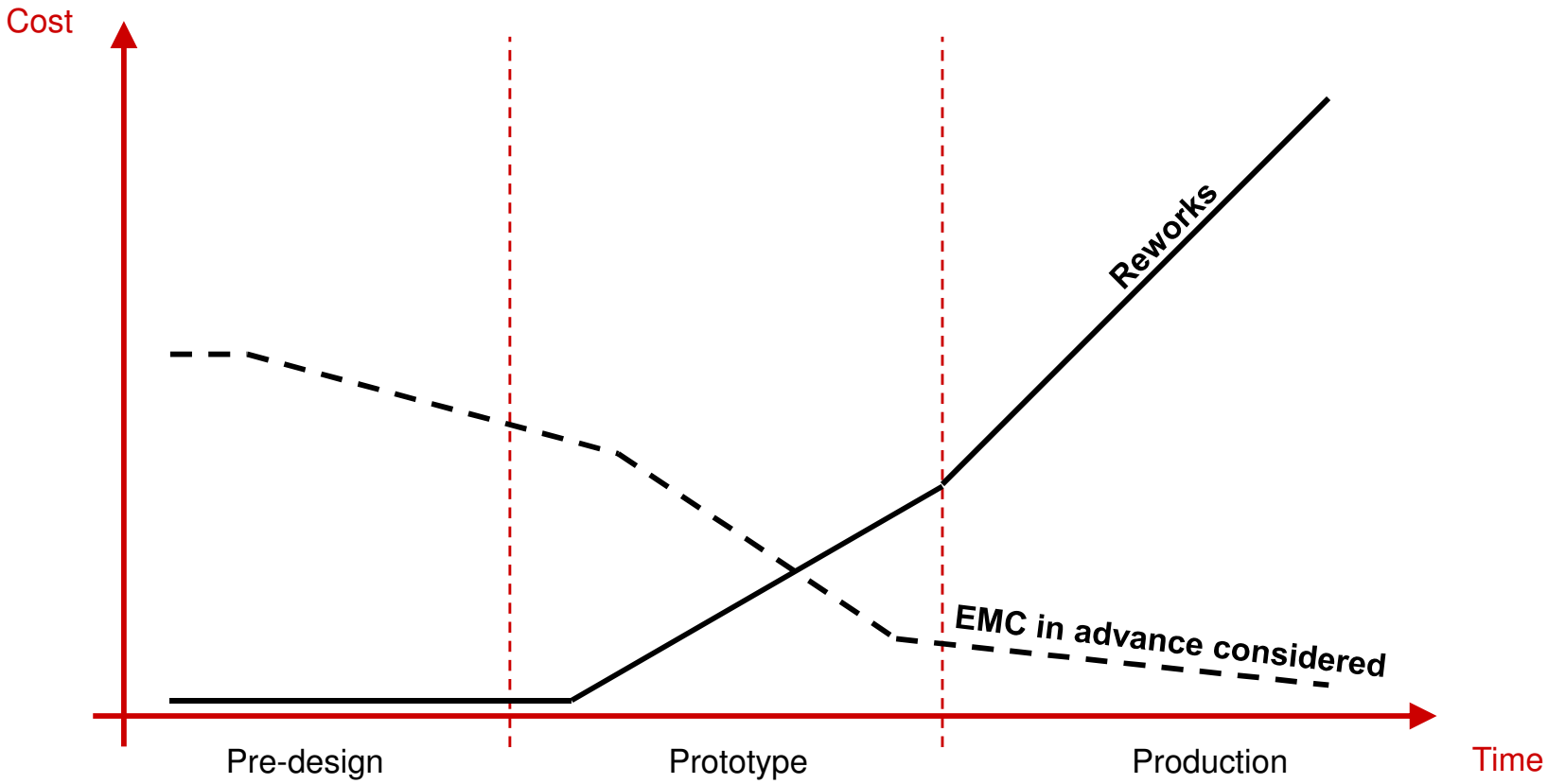
What's all the fuss about EMC?

- In Europe, we have a mechanism called CE Marking
- It is applicable to <u>any electrical/electronic product</u>
- **EMC Directive**, regulation to ensure that intentional RF transmission signals are not interfered with
- Ensures that Electrical/Electronic devices continue to operate as intended in a Electro Magnetic Environment
- Failure to comply with the law can be a offence, either criminal, civil or both

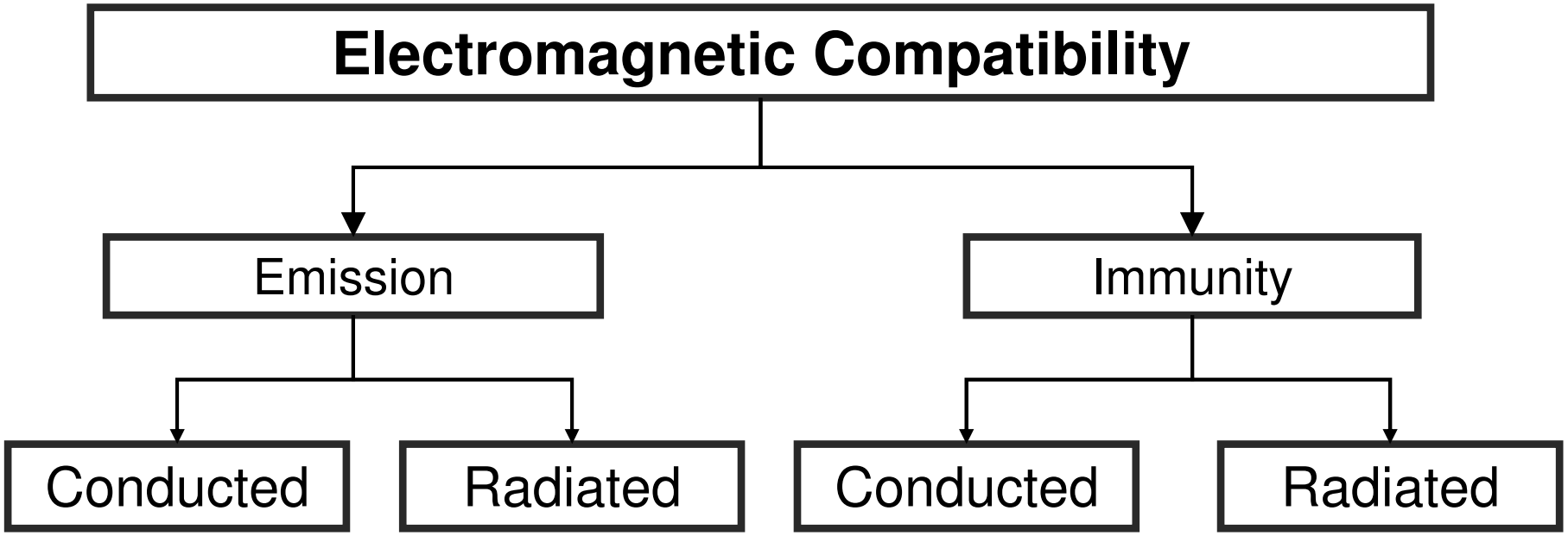
EMC Effect

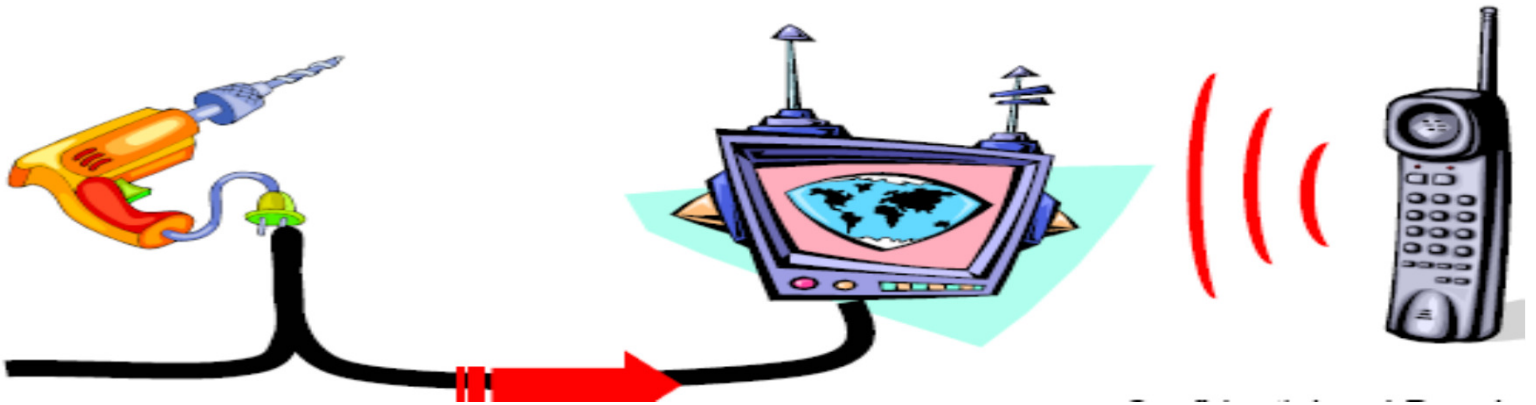
Economical point of view:

- dependent on when EMC conformity is considered in a design phase



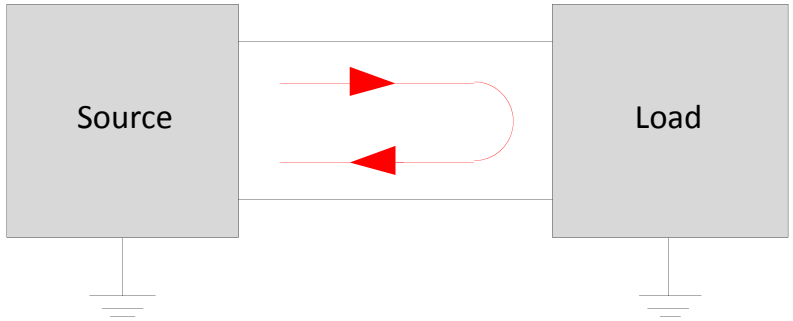
EMC – Basic Phenomena





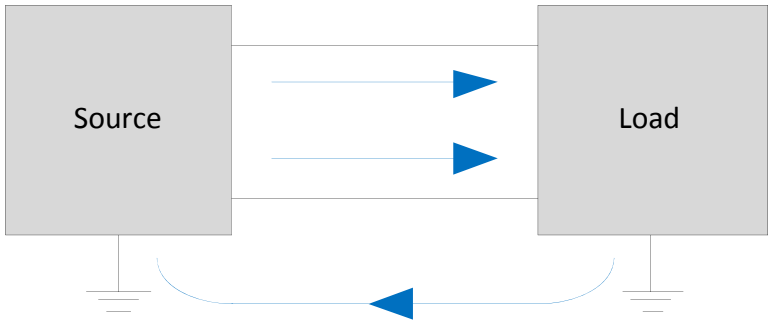
Filter and Signal – Common Mode Filter

differential mode



- Source transmits noise in differential mode
- Differential mode noise is transmitted via conductive paths
- Transmitting paths are power supply or data lines
- *"earth"* is not affected by noise

common mode



- Load is disturbed by common mode noise
- Noise flow from source to load. The return path is over *"earth"*
- Transmitting paths are power supply or data lines
- *"earth"* is affected by noise

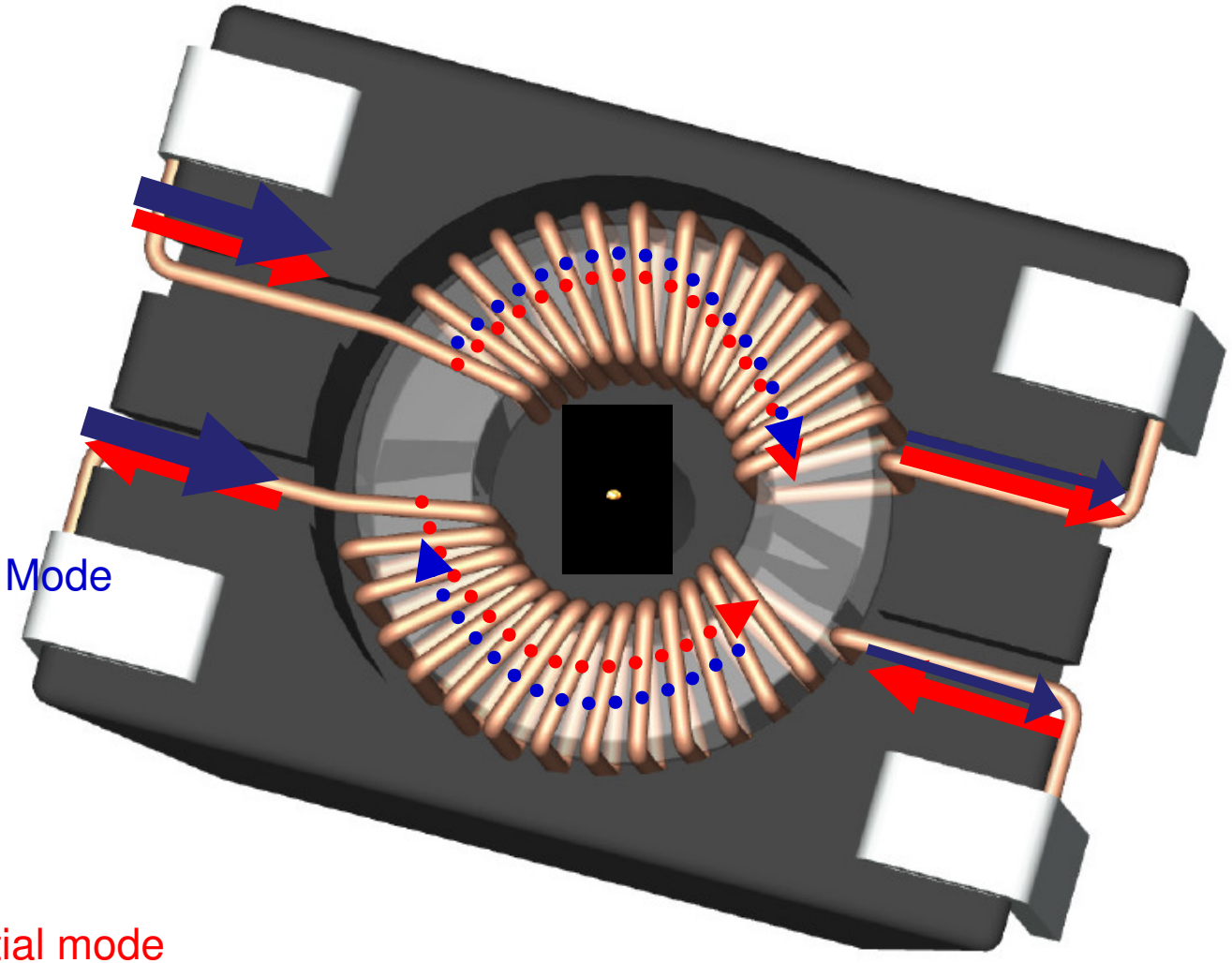
Common Mode Filter – How it works

It is a Bi-directional filter

- From device to outside environment
- From outside environment to inside device

Intended Signal - Differential mode

Interference Signal (noise) – Common Mode



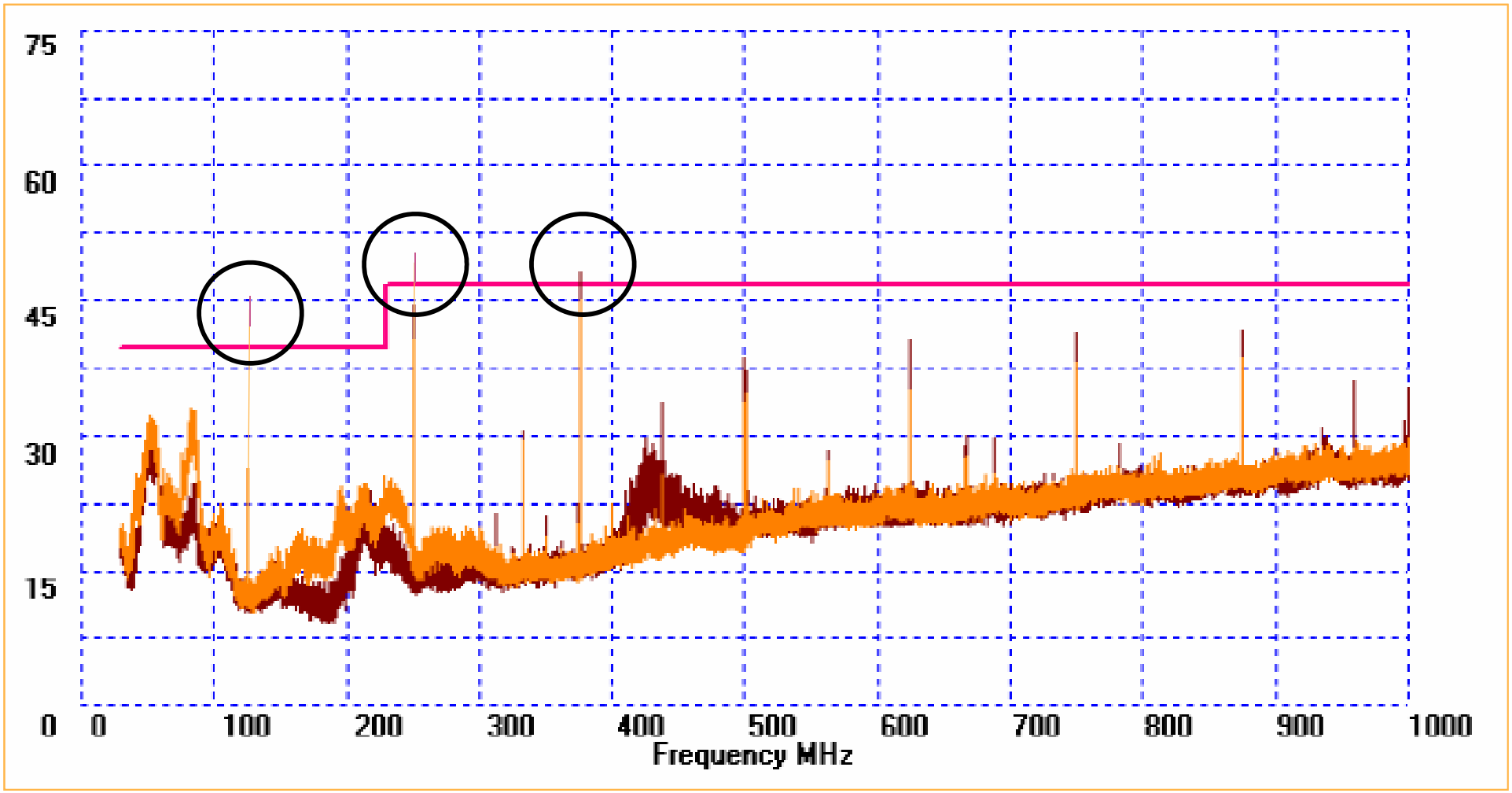
Conclusion:

- “almost” no affect the signal - Differential mode
- high attenuation to the interference signal (noise) – Common Mode

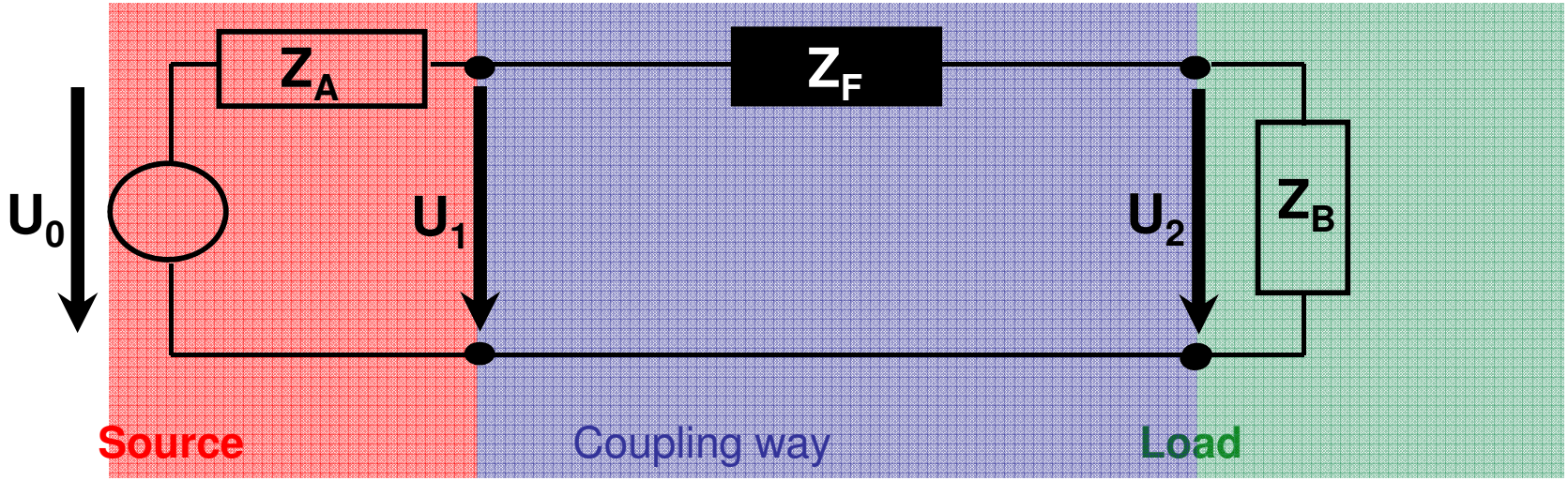
INSERTION LOSS

The problem

- **Example, Radiated Emission plot**



Insertion Loss – Definition



- System attenuation

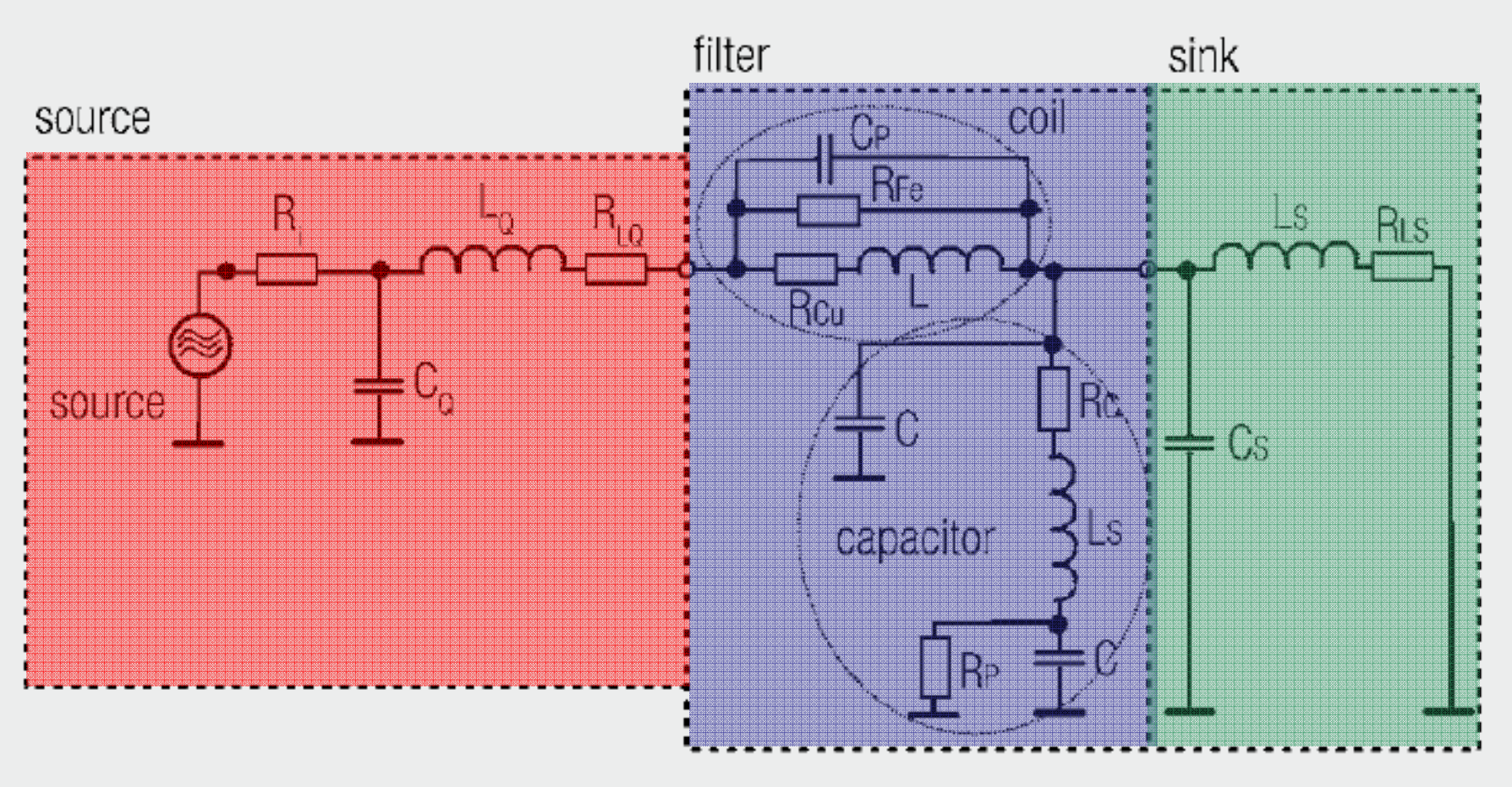
$$A = 20 \cdot \log \frac{Z_A + Z_F + Z_B}{Z_A + Z_B} \quad in\ (dB)$$

- Impedance

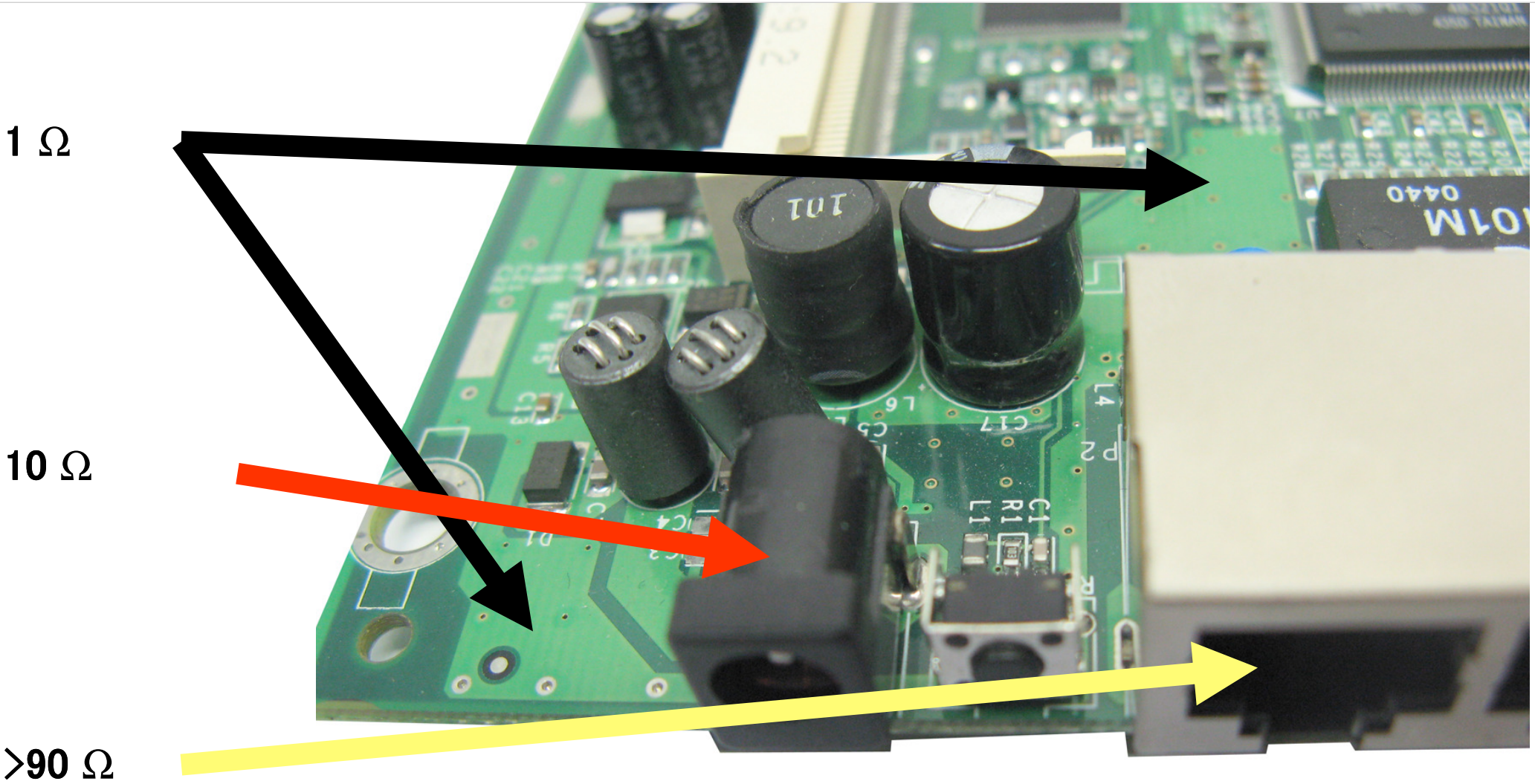
$$Z_F = \left[10^{\frac{A}{20}} \cdot (Z_A + Z_B) \right] - (Z_A + Z_B) \quad in\ (\Omega)$$

Insertion loss

- **The real world – equivalent circuit**



System impedances



The mathematical approach

$$Z_F = \left[10^{\frac{A}{20}} \cdot (Z_A + Z_B) \right] - (Z_A + Z_B)$$

$$Z_F = \left[10^{\frac{20}{20}} \cdot (10_A + 10_B) \right] - (10_A + 10_B)$$

$$Z_F = 180\Omega$$

Application overview	
Assumend practical system impedance	**Application**
1 Ω	GND (Ground Planes)
10 Ω	V_{cc} (Supply Voltage lines)
50 Ω – 90 Ω	Datasignal Lines/Clock/ Video Signal/USB
90 Ω – 150 Ω	Long Datasignal Lines

1. **Require 20dB of attenuation at 200 MHz**
2. **Know that it is a power cable**
3. **Power port has 10 Ω impedance**
4. **Result is a impedance of 180 Ω**

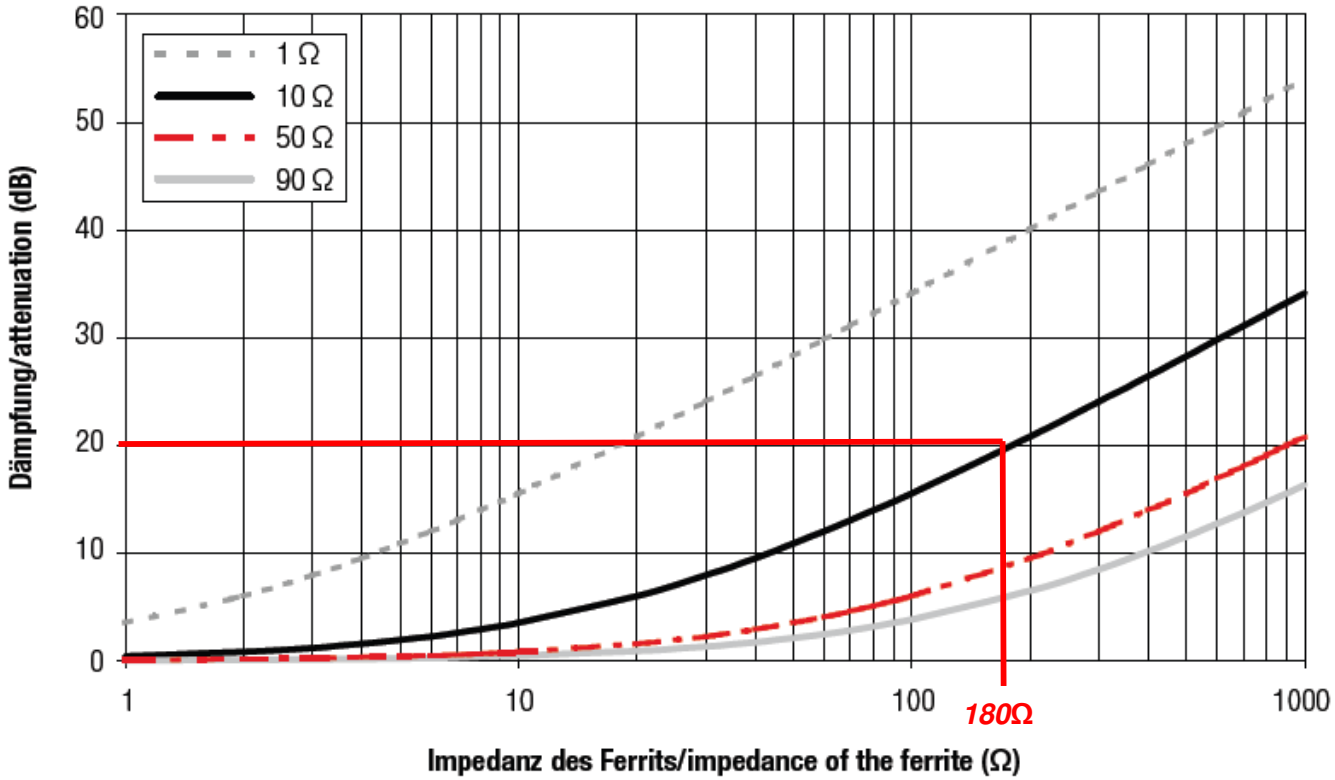
$$A = 20 \log \frac{Z_A + Z_F + Z_B}{Z_A + Z_B}$$

$$A = 20 \log \frac{10_A + 180_F + 10_B}{10_A + 10_B}$$

$$A = 20 \log 10$$

$$A = 20.00\, dB$$

The practical approach



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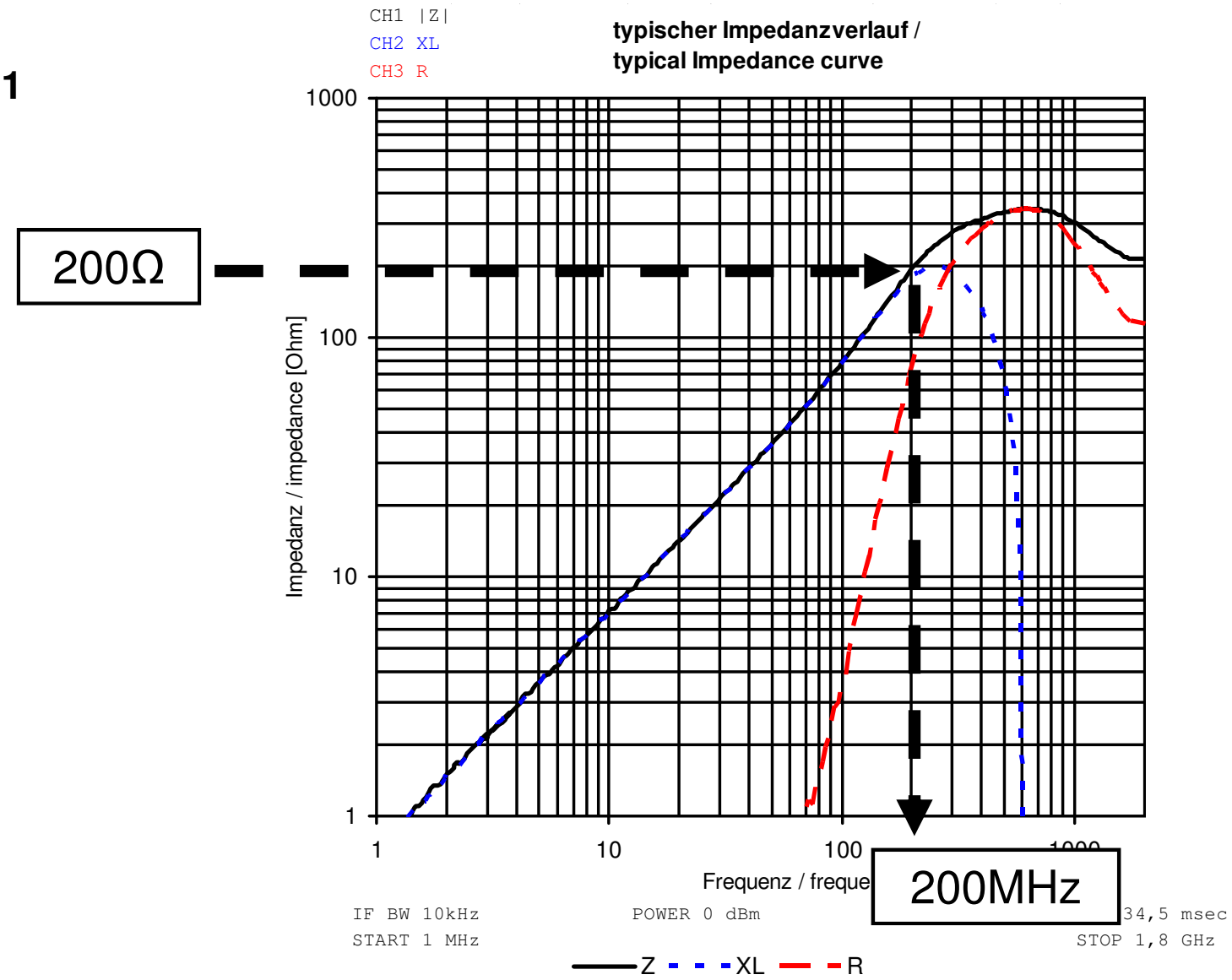
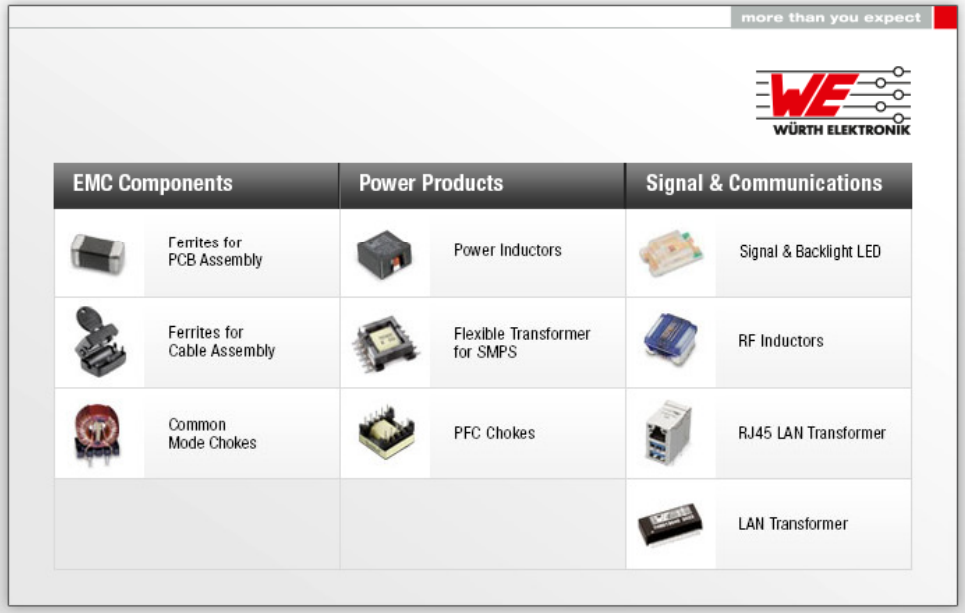
Insertion loss – Example

- **WE-CBF 742 792 61**

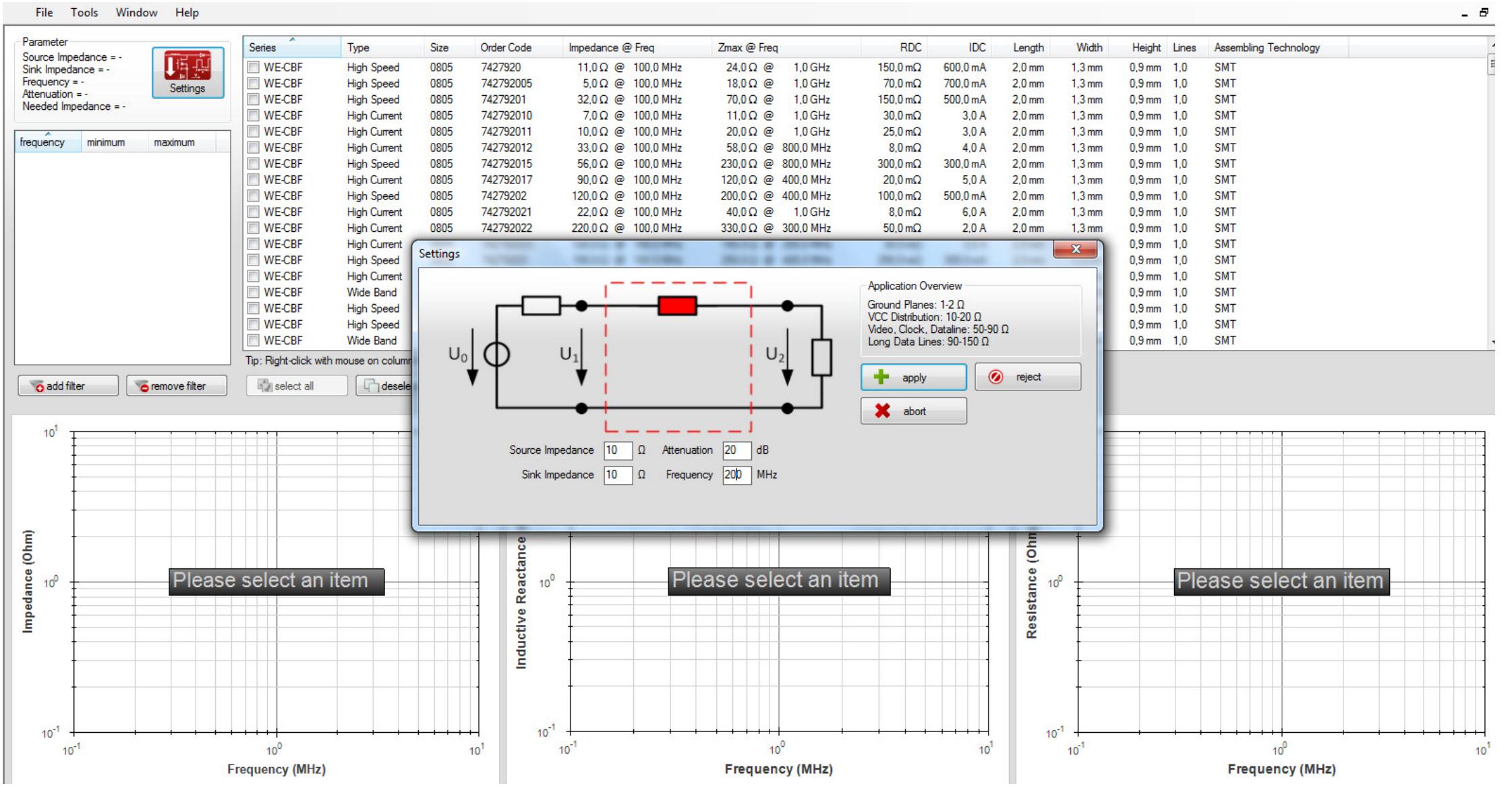


Component selector

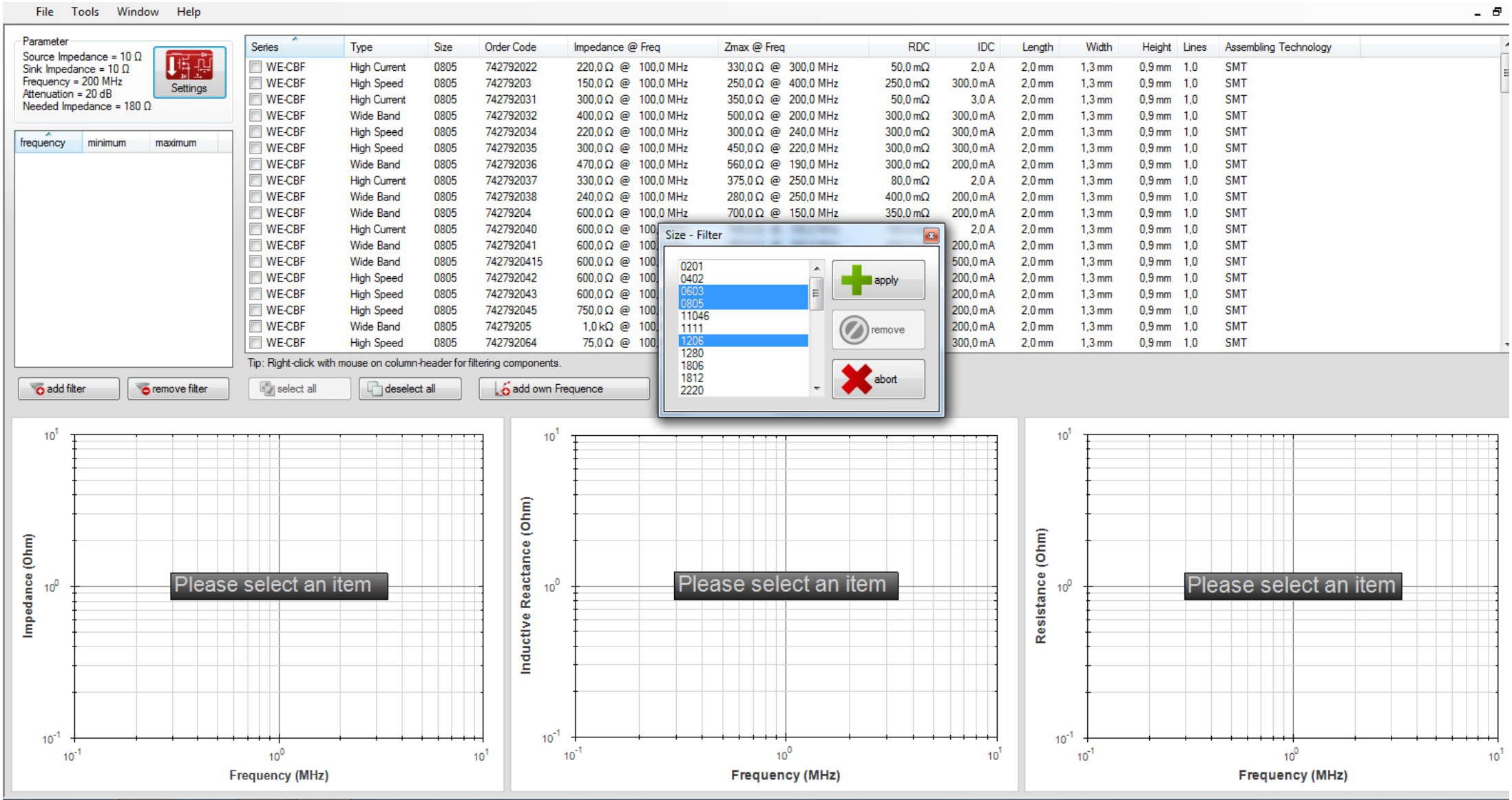
File Tools Window Help



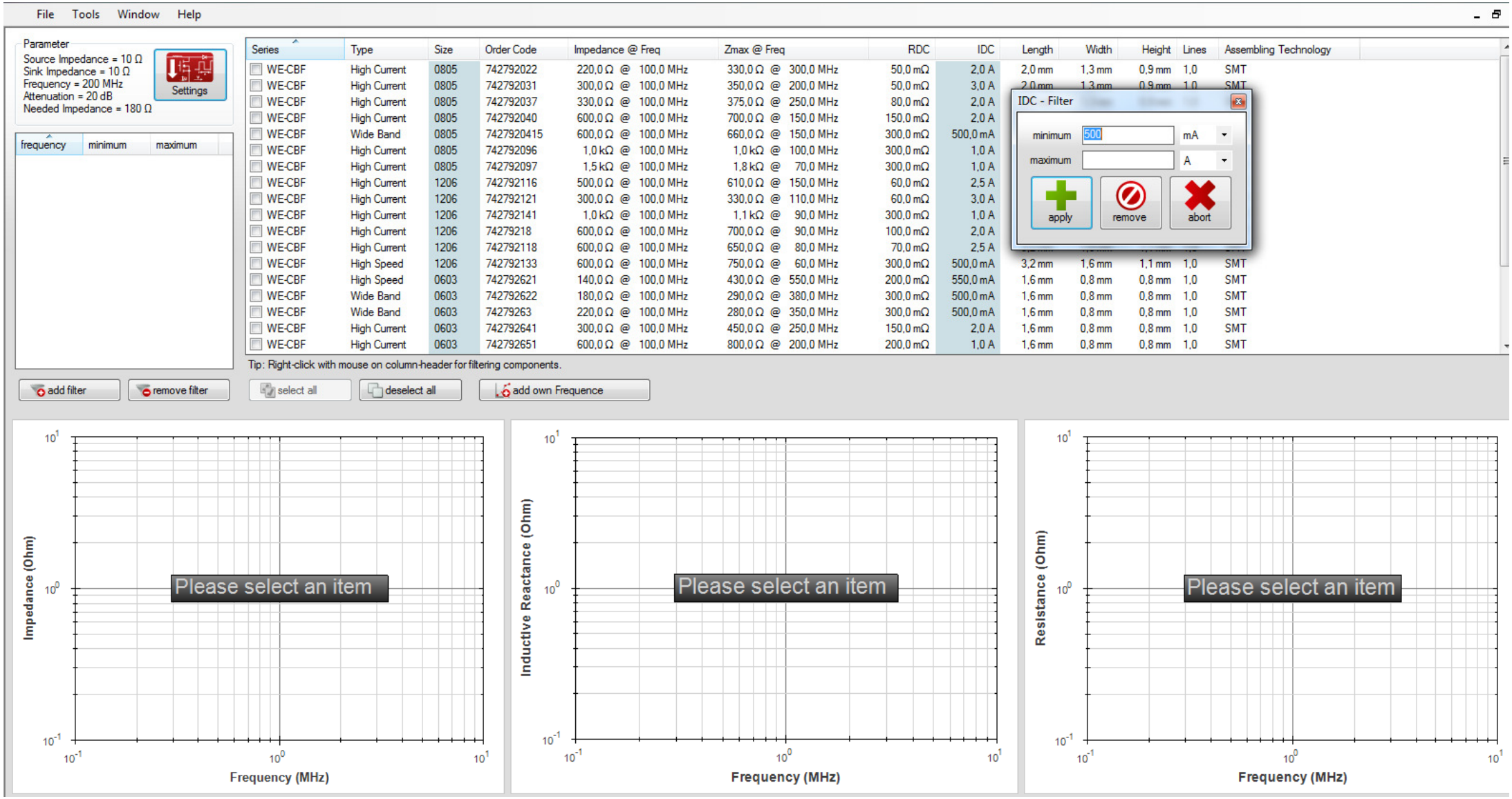
Component selector



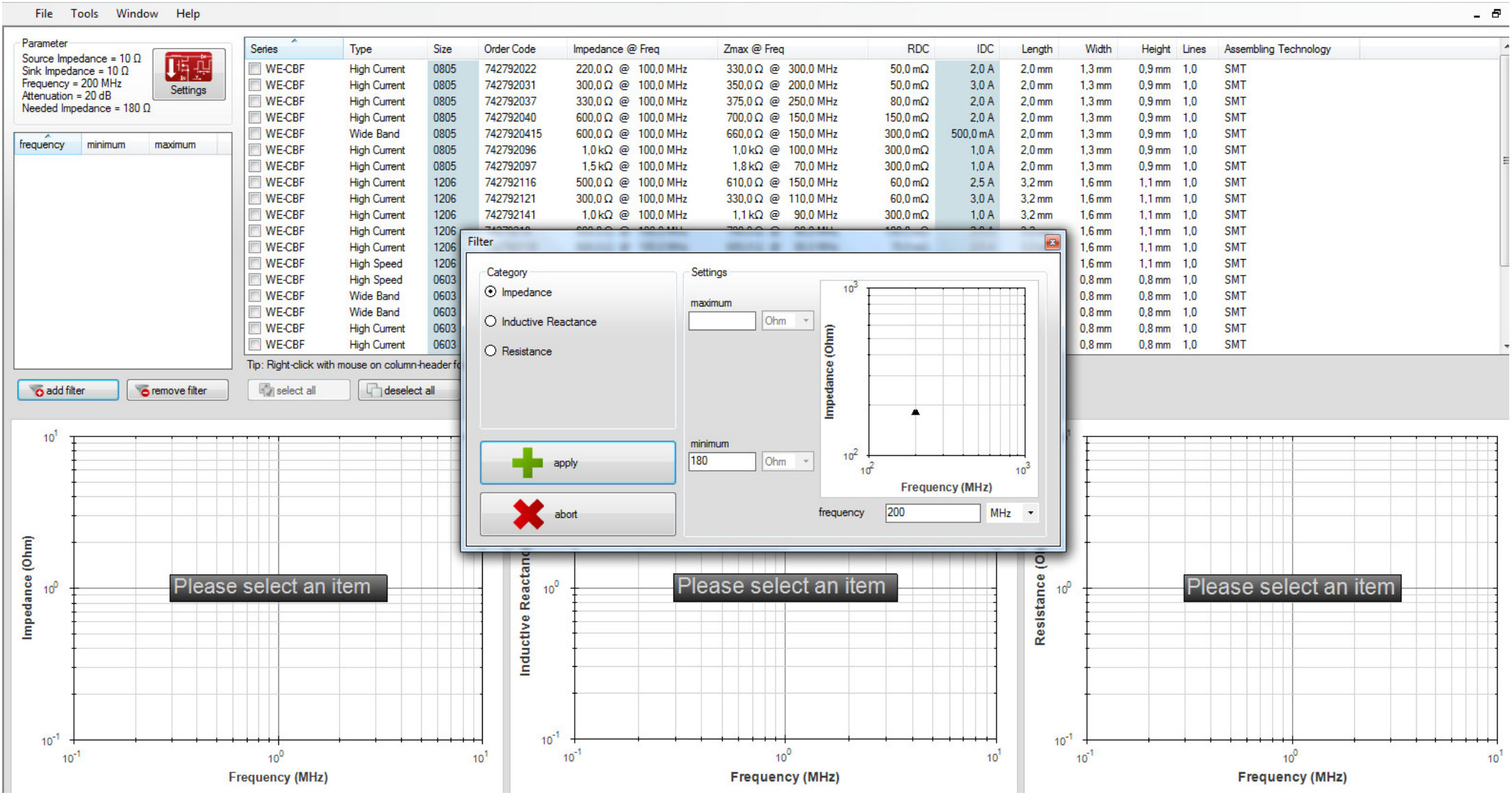
Component selector



Component selector



Component selector



Component selector

File Tools Window Help

Parameter
Source Impedance = 10 Ω
Sink Impedance = 10 Ω
Frequency = 200 MHz
Attenuation = 20 dB
Needed Impedance = 180 Ω

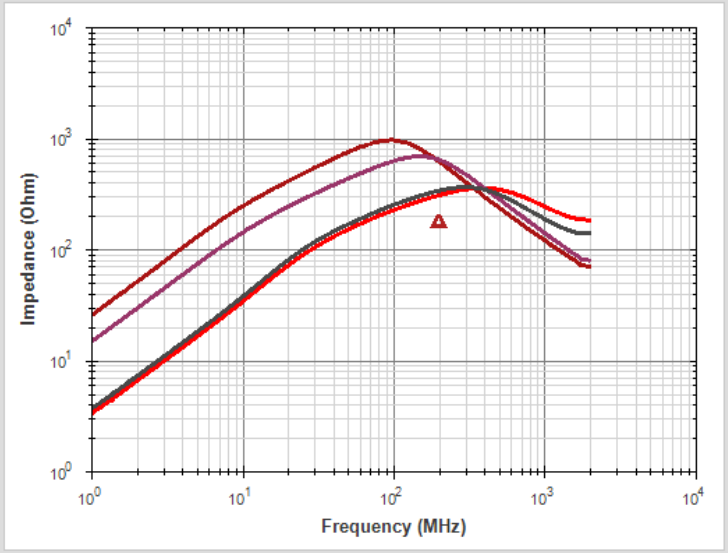
Settings

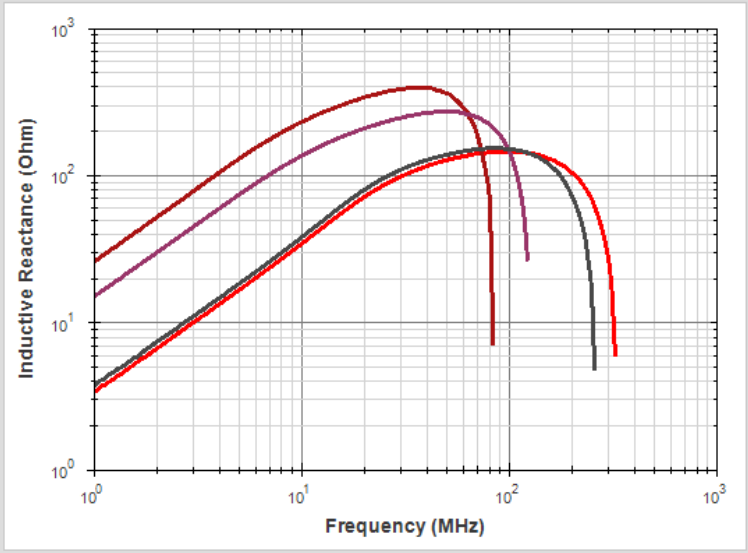
frequency	minimum	maximum
Impedance		
200 MHz	180 Ohm	-

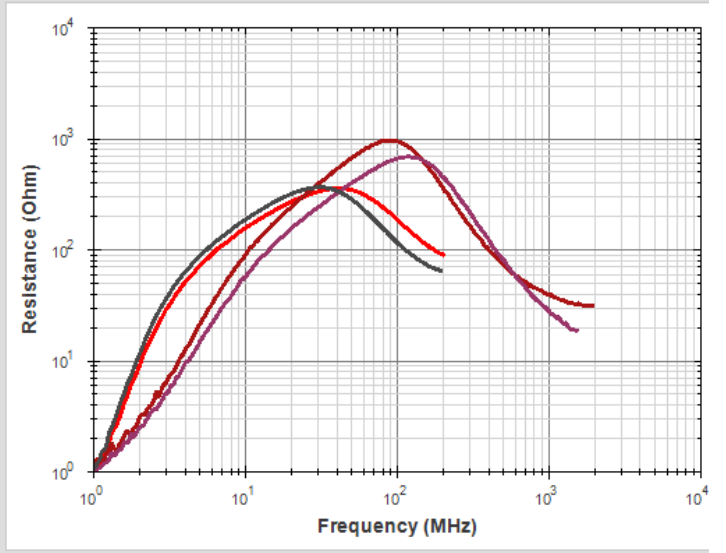
Series	Type	Size	Order Code	Impedance @ Freq	Zmax @ Freq	RDC	IDC	Length	Width	Height	Lines	Assembling Technology
☑ WE-CBF	High Current	0805	742792022	220,0 Ω @ 100,0 MHz	330,0 Ω @ 300,0 MHz	50,0 mΩ	2,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	0805	742792031	300,0 Ω @ 100,0 MHz	350,0 Ω @ 200,0 MHz	50,0 mΩ	3,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	0805	742792037	330,0 Ω @ 100,0 MHz	375,0 Ω @ 250,0 MHz	80,0 mΩ	2,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	0805	742792040	600,0 Ω @ 100,0 MHz	700,0 Ω @ 150,0 MHz	150,0 mΩ	2,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☑ WE-CBF	Wide Band	0805	7427920415	600,0 Ω @ 100,0 MHz	660,0 Ω @ 150,0 MHz	300,0 mΩ	500,0 mA	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	0805	742792096	1,0 kΩ @ 100,0 MHz	1,0 kΩ @ 100,0 MHz	300,0 mΩ	1,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	0805	742792097	1,5 kΩ @ 100,0 MHz	1,8 kΩ @ 70,0 MHz	300,0 mΩ	1,0 A	2,0 mm	1,3 mm	0,9 mm	1,0	SMT
☐ WE-CBF	High Current	1206	742792116	500,0 Ω @ 100,0 MHz	610,0 Ω @ 150,0 MHz	60,0 mΩ	2,5 A	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☐ WE-CBF	High Current	1206	742792121	300,0 Ω @ 100,0 MHz	330,0 Ω @ 110,0 MHz	60,0 mΩ	3,0 A	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☑ WE-CBF	High Current	1206	742792141	1,0 kΩ @ 100,0 MHz	1,1 kΩ @ 90,0 MHz	300,0 mΩ	1,0 A	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☐ WE-CBF	High Current	1206	74279218	600,0 Ω @ 100,0 MHz	700,0 Ω @ 90,0 MHz	100,0 mΩ	2,0 A	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☐ WE-CBF	High Current	1206	742792118	600,0 Ω @ 100,0 MHz	650,0 Ω @ 80,0 MHz	70,0 mΩ	2,5 A	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☐ WE-CBF	High Speed	1206	742792133	600,0 Ω @ 100,0 MHz	750,0 Ω @ 60,0 MHz	300,0 mΩ	500,0 mA	3,2 mm	1,6 mm	1,1 mm	1,0	SMT
☐ WE-CBF	High Speed	0603	742792621	140,0 Ω @ 100,0 MHz	430,0 Ω @ 550,0 MHz	200,0 mΩ	550,0 mA	1,6 mm	0,8 mm	0,8 mm	1,0	SMT
☐ WE-CBF	Wide Band	0603	742792622	180,0 Ω @ 100,0 MHz	290,0 Ω @ 380,0 MHz	300,0 mΩ	500,0 mA	1,6 mm	0,8 mm	0,8 mm	1,0	SMT
☐ WE-CBF	Wide Band	0603	74279263	220,0 Ω @ 100,0 MHz	280,0 Ω @ 350,0 MHz	300,0 mΩ	500,0 mA	1,6 mm	0,8 mm	0,8 mm	1,0	SMT
☐ WE-CBF	High Current	0603	742792641	300,0 Ω @ 100,0 MHz	450,0 Ω @ 250,0 MHz	150,0 mΩ	2,0 A	1,6 mm	0,8 mm	0,8 mm	1,0	SMT
☐ WE-CBF	High Current	0603	742792651	600,0 Ω @ 100,0 MHz	800,0 Ω @ 200,0 MHz	200,0 mΩ	1,0 A	1,6 mm	0,8 mm	0,8 mm	1,0	SMT

Tip: Right-click with mouse on column-header for filtering components.

add filter | remove filter | select all | deselect all | add own Frequence



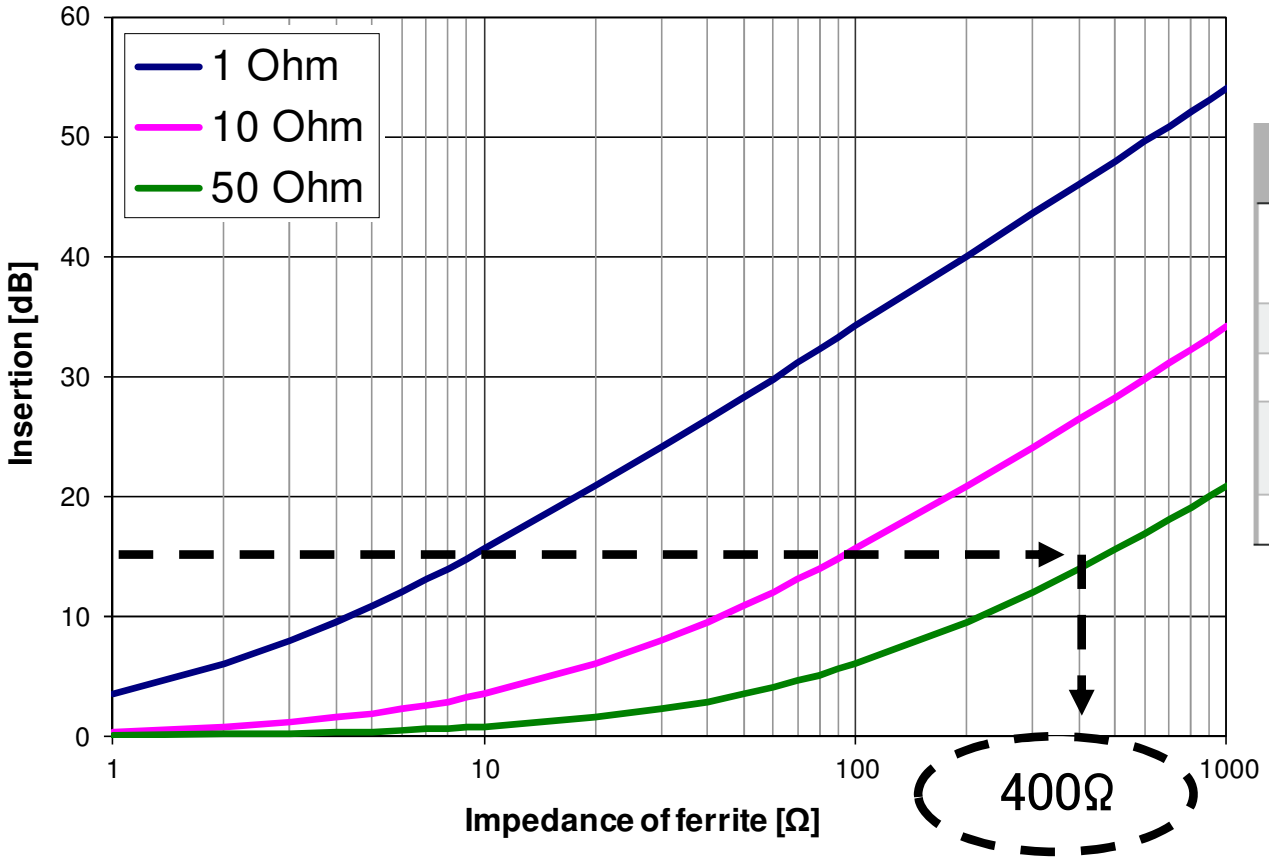




Insertion loss - example

→ Application: sensor line, cable diameter 5mm

→ 15dB @ 200 MHz



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90 Ω – 150 Ω	Long Datasignal Lines

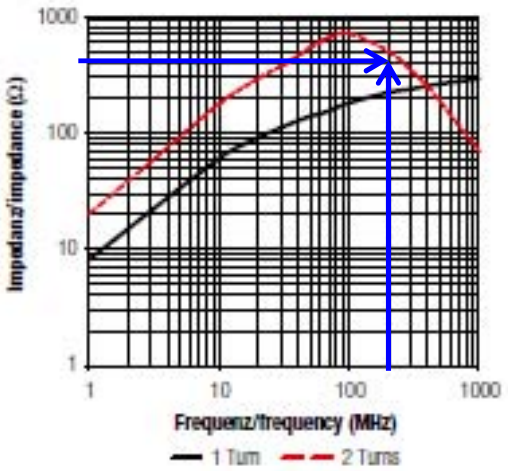
- System impedance = 50 Ω

Star-Tec

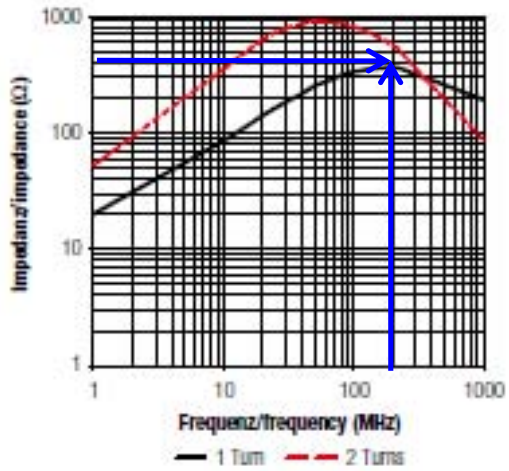
Electrical properties

Order Code	A (mm)	B (mm)	C (mm)	Colour	Z @ 25 MHz (Ω) 1 Turn	Z @ 100 MHz (Ω) 1 Turn	Z @ 25 MHz (Ω) 2 Turns	Z @ 100 MHz (Ω) 2 Turns	Cable ∅ (mm)	Material	Order Code Fixation
742 711 42	32.5	18.8	13.2	grey	98	182	401	709	3.5–5.0		–
742 711 42S	32.5	18.8	13.2	black	98	182	401	709	3.5–5.0		–
742 711 11*	40.5	23.7	18.2	grey	175	320	770	800	3.5–5.0		**742 771 1**
742 711 11S*	40.5	23.7	18.2	black	175	320	770	800	3.5–5.0		**742 771 1**
742 711 12*	40.5	23.7	18.2	grey	176	321	773	806	4.5–6.0		**742 771 1**

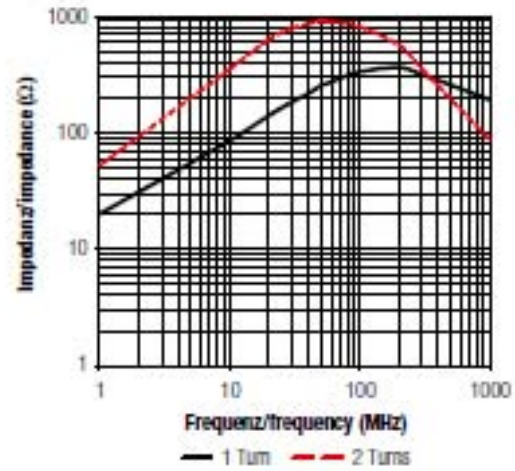
742 711 42 / 742 711 42S



742 711 11 / 742 711 11S



742 711 12 / 742 711 12S

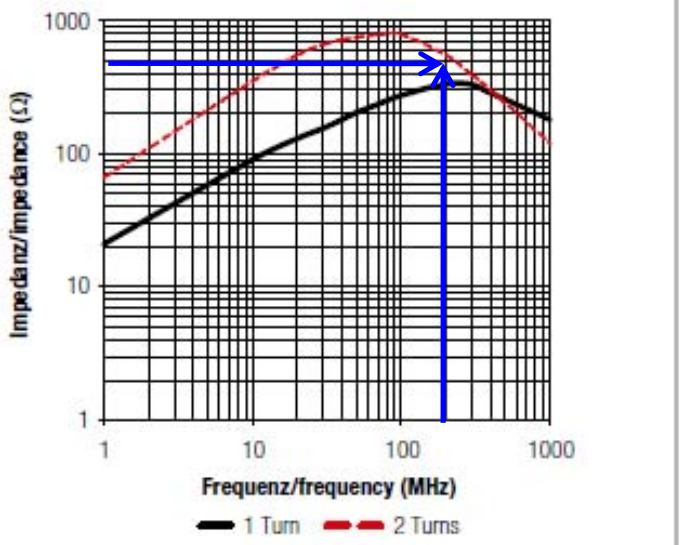


Star-Tec

Electrical properties

Order Code	A (mm)	B (mm)	C (mm)	Colour	Z @ 25 MHz (Ω) 1 Turn	Z @ 100 MHz (Ω) 1 Turn	Z @ 25 MHz (Ω) 2 Turns	Z @ 100 MHz (Ω) 2 Turns	Cable ∅ (mm)	Material	Order Code Fixation
742 712 22	42.2	33.5	28.8	grey	145	265	638	779	10.5–12.5		–
742 712 22S	42.2	33.5	28.8	black	145	265	638	779	10.5–12.5		–

742 712 22 / 742 712 22S

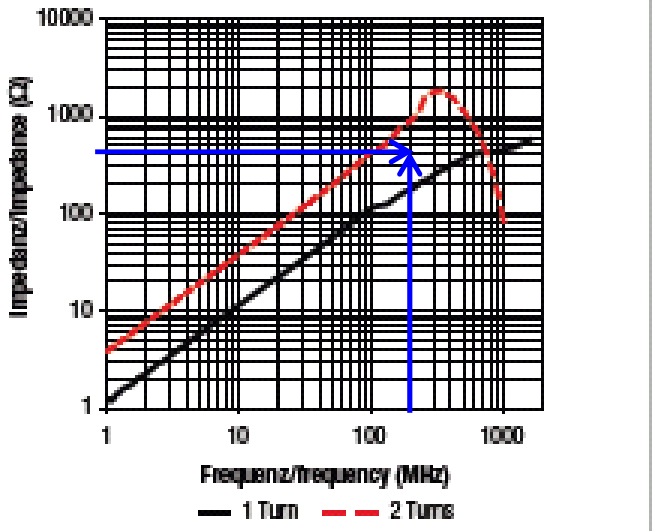


Star-Gap

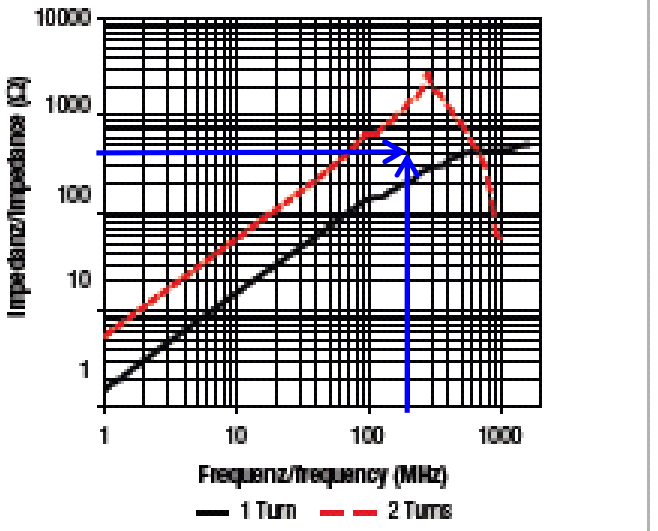
Electrical properties

Order Code	A (mm)	B (mm)	C (mm)	Colour	Z @ 25 MHz (Ω) 1 Turn	Z @ 100 MHz (Ω) 1 Turn	Z @ 200 MHz (Ω) 1 Turn	Z @ 300 MHz (Ω) 1 Turn	Z @ 500 MHz (Ω) 1 Turn	Z @ 25 MHz (Ω) 2 Turns	Z @ 100 MHz (Ω) 2 Turns	Z @ 200 MHz (Ω) 2 Turns	Z @ 300 MHz (Ω) 2 Turns	Z @ 500 MHz (Ω) 2 Turns	Cable ∅ (mm)	Material	Order Code Fixation
742 716 33*	35.1	21.7	19.0	grey	28	100	190	250	345	90	400	900	1750	1100	4.5–8.0	4 W 620	**742 771 1**
742 716 33S*	35.1	21.7	19.0	black	28	100	190	250	345	90	400	900	1750	1100	4.5–8.0		**742 771 1**
742 716 22	35.0	31.5	28.3	grey	35	140	200	300	400	135	640	1400	1900	830	8.5–12.5		–
742 716 22S	35.0	31.5	28.3	black	35	140	200	300	400	135	640	1400	1900	830	8.5–12.5		–

742 716 33 / 742 716 33S

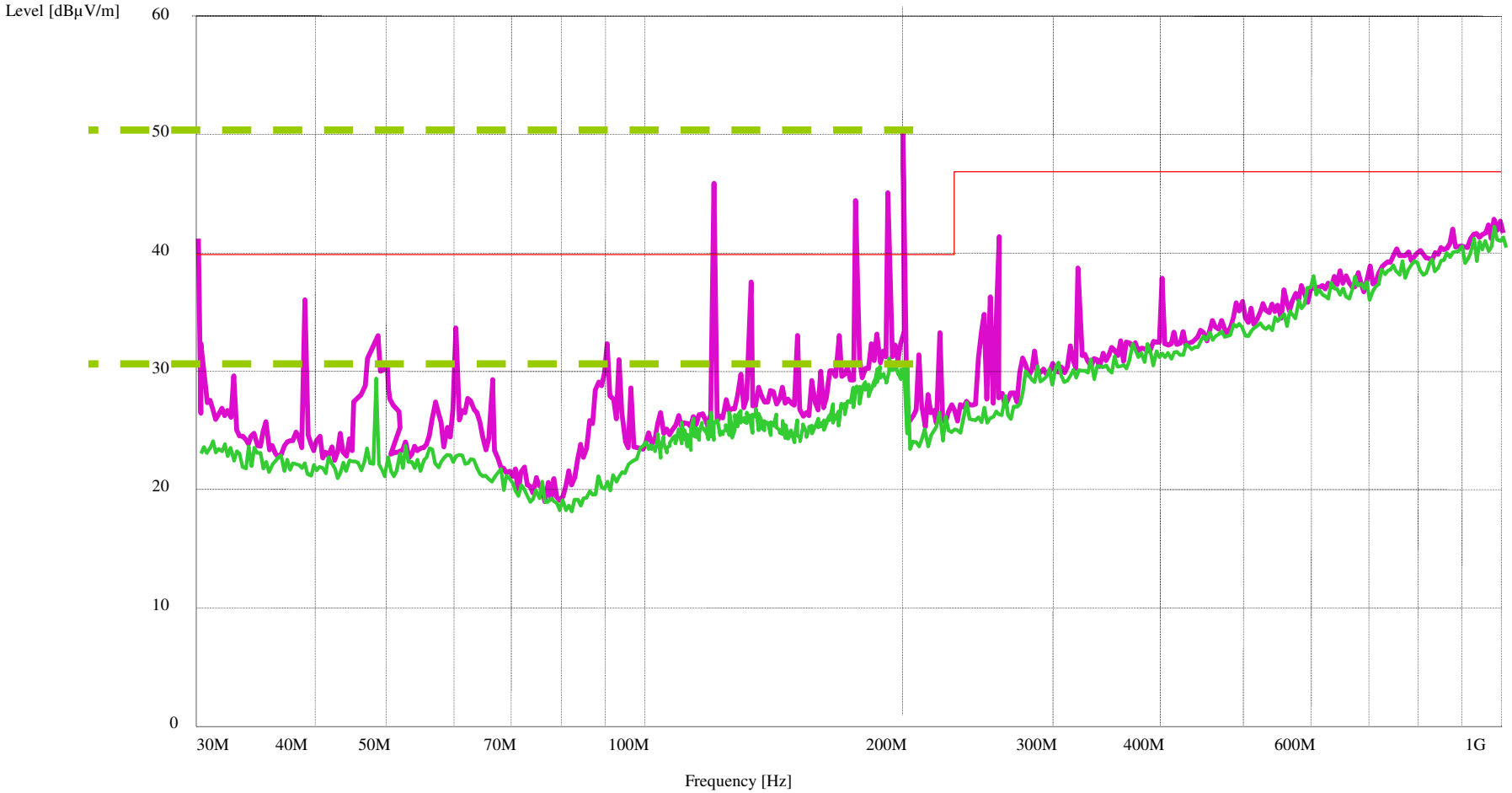


742 716 22 / 742 716 22S



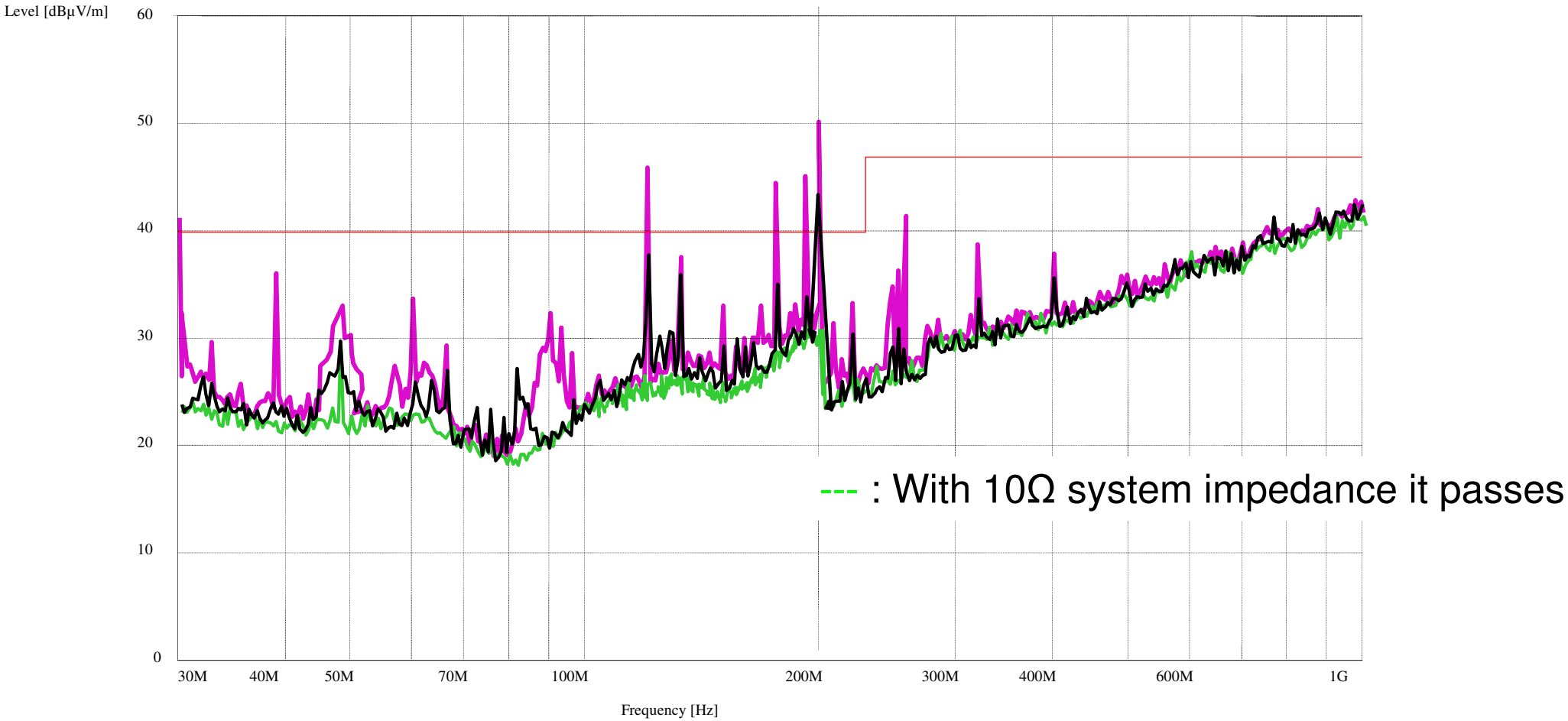
Insertion loss – Example

- **Check the results**
  - **Measuring the emission and compare the attenuation**



Insertion loss – Example

- **Choosing different system impedance**



DESIGN GUIDES

Trilogy of Magnetics

- **Now published as 4th edition**
- **Three sections:**

  Magnetic basics

  Components

  Application notes

  Filtering

  DC/DC PSU design

THANK YOU

Any Questions?